(51) Int. Cl.^{6}	Id. No.	Office Reg. No.	Fl	Techn. Ind. Field.
B60Q 1/14	A			
	F			
	H			
B60Q 1/08				
F21M 3/18				

Examination Request: None   No. of Claims: 2 OL (total pages 8)
Continued on the last page

Continued on the last page

(54) [Title of the Invention] HEADLAMP UNIT FOR VEHICLES

(57) [Abstract]

[Object] To project light with optimum brightness viewed by the driver, without producing no glare to other vehicles.

[Structure] The distance S_L between the vehicles (preceding vehicle), distance S_R between the vehicles (oncoming vehicle), and brightness L of the environment are read and the variation quantity dS_R of distance S_R is computed (202-206). When the variation quantity dS_R is small (208) and the environment is dark, the voltage value is set from the dark map for a normal approach, and when it is light, the voltage value is set from the light map for a normal approach (210-214), and the brightness of the lamp is controlled according to the set voltage value and variation rate (216, 218). When the variation quantity dS_R is large (220) and the environment

dark, the voltage value is set (222) from the dark map for a rapid approach, and when it is light, the voltage value is set (224) from the light map for a rapid approach, and the brightness of the lamp is controlled according to the set voltage value (218). Therefore, the headlamp light corresponding to the approach state of the other vehicle and the brightness of environment is projected forward.

[Patent Claims]

[Claim 1] A headlamp unit for a vehicle, comprising:
a headlamp with a variable illumination state depending on at least one parameter from illumination direction, illumination range, and brightness;
movement state detection means for detecting the movement state of the other vehicle traveling in front of the own vehicle; and
control means for controlling at least one parameter from illumination direction, illumination range, and brightness of said headlamp based on the detected movement state.

[Claim 2] A headlamp unit for a vehicle, comprising:
a headlamp with a variable illumination state depending on at least one parameter from illumination direction, illumination range, and brightness;
movement state detection means for detecting the movement state of the other vehicle traveling in front of the own vehicle;
brightness detection means for detecting the brightness around said other vehicle; and
control means for controlling at least one from illumination direction, illumination range, and brightness of said headlamp based on the detected brightness and movement state.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Application] The present invention relates to a headlamp unit for a vehicle, more specifically, to a headlamp unit for a vehicle for controlling the light distribution of the headlamp projecting light in front of the vehicle.

[0002]

[Prior Art Technology] In order to improve forward visibility for the driver, e.g., in the nighttime, the vehicles are provided with headlamps with a light distribution that can be switched between a state of illuminating the region far from the vehicle with a high quantity of light and a state of illuminating the region close to the vehicle with a low quantity of light (a high beam mode and a low beam mode, respectively). Such headlamps are secured to the front end of the vehicle and illuminate the predetermined comparatively wide range.

[0003] On the usual road where a car provided with such headlamps is driven, an oncoming vehicle passing by the own vehicle may be present in front of the own vehicle. If the headlamps are in a state of illuminating a distant area when an oncoming vehicle is thus present in front of the

2

own vehicle, light with a large quantity is projected toward the oncoming vehicle and the driver of the oncoming vehicle experiences glare. For this reason, a device for controlling the quantity of light has been suggested (Japanese Utility Model Application Laid-open No. 63-129641) in which the quantity of light around the own vehicle, which includes the light from the headlamps of an oncoming vehicle, is detected with a sensor and the quantity of light of the headlamps of the own vehicle is controlled based on the detected value.

[0004]

[Problems Addressed by the Invention] However, the degree to which the driver of the other vehicle, such as a preceding vehicle or oncoming vehicle, experiences glare is affected by the manner in which the own vehicle and other vehicle approach each other or emerge in front of each other. For example, when the oncoming vehicle approaches the own vehicle, two modes of approach are possible: a normal approach mode which is characterized by gradual approach and a rapid approach mode in which the oncoming vehicle appears, e.g., in the intersection. The degree to which glare is experienced is higher in the rapid approach mode even if the quantity of light and the distance between the vehicles are the same. Therefore, the driver of the oncoming vehicle sometimes experiences glare when the quantity of light of the headlamps of the own vehicle is simply controlled by the quantity of light of the headlamps of the oncoming vehicle projecting light toward the own vehicle, as in the above-described light control unit.

[0005] Furthermore, the brightness of the headlamps of the own vehicle which caused the driver of the oncoming vehicle to experience glare is affected by the brightness around the road. For example, in the cities with intensive external illumination and a large quantity of light from the buildings, even if glare is not caused by the brightness of headlamps, glare can be experienced on the roads with a small number of surrounding objects scattering the light. Therefore, the driver of the oncoming vehicle sometimes experiences glare caused by the headlamps of the own vehicle due to conditions around the road.

[0006] With the foregoing in view, it is an object of the present invention to provide a headlamp unit for a vehicle that can project light of optimum brightness for the driver, without causing glare to the oncoming vehicle.

[0007]

[Means to Attain the Object] In order to attain the above-described object, the present invention, as described in claim 1, provides a headlamp unit for a vehicle, comprising a headlamp with a variable illumination state depending on at least one parameter from illumination direction, illumination range, and brightness, movement state detection means for detecting the movement state of the other vehicle traveling in front of the own vehicle, and control means for controlling at least one parameter from illumination direction, illumination range, and brightness of the headlamp based on the detected movement state.

[0008] Furthermore, the present invention, as described in claim 2, provides a headlamp unit for a vehicle, comprising a headlamp with a variable illumination state depending on at least one

parameter from illumination direction, illumination range, and brightness, movement state detection means for detecting the movement state of the other vehicle traveling in front of the own vehicle, brightness detection means for detecting the brightness around the other vehicle, and control means for controlling at least one parameter from illumination direction, illumination range, and brightness of the headlamp based on the detected brightness and movement state.

[0009]

[Operation] The headlamp unit for a vehicle in accordance with the present invention, as disclosed in claim 1, comprises a headlamp with a variable illumination state depending on at least one parameter of illumination direction, illumination range, and brightness. Movement state detection means detects the movement state of the other vehicle traveling in front of the own vehicle. The other vehicle may be a preceding vehicle traveling in the same direction as the own vehicle in front of the own vehicle or an oncoming vehicle traveling in the direction opposite that of the own vehicle. Furthermore, the movement state may be a state in which the distance to the other vehicle increases and that in which the distance to the other vehicle decreases. In particular, in terms of approaching the oncoming vehicle, there are oncoming vehicles that travel in the normal oncoming direction and those that emerge suddenly so as to advance into the road where the own vehicle travels, such a situation occurring in intersections and the like. Control means controls at least one parameter of the headlamp illumination direction, illumination range, and brightness based on the detected movement state. Therefore, because the illumination state of the headlamps is changed according to the movement state of the other vehicle, the optimum illumination state of the headlamps can be set for a state in which the other vehicle approaches, moves away, and appears suddenly.

[0010] Further, the headlamp unit for a vehicle in accordance with the present invention, as disclosed in claim 2, comprises brightness detection means for detecting brightness around the other vehicle. This brightness around the other vehicle can be detected from the value of quantity of light obtained when the prescribed range where the other vehicle is present is photographed and also can be evaluated from the detected brightness around the own vehicle. Control means controls the brightness of the headlamps based on the detected brightness and movement state. As a result, the headlamps of the own vehicle can be operated in the optimum state taking into account the effect of glare experienced by the driver of the other vehicle owing to the brightness of the environment where the own vehicle and the other vehicle travel.

[0011]

[Embodiment] An embodiment of the present invention will be described hereinbelow with reference to the appended drawings. In the below-described embodiment, the headlamp unit for an automobile in accordance with the present invention is applied to a headlamp control unit for controlling the distribution of light in the headlamps arranged on the front side of the vehicles. The arrows FR, UP, LH, and RH in the figure show the forward, upward, leftward, and rightward direction of the vehicle, respectively.

[0012] As shown in FIG. 1, an engine hood 12 is located in the upper surface portion of a front

body 10A of a vehicle 10 and a pair of left and right (at both ends in the lateral direction of the vehicle) headlamps 18, 20 are disposed above the front bumper 16 secured at both ends in the lateral direction of the vehicle at the front end portion of the front body 10A. Furthermore, a windshield glass 14 is provided close to the rear end portion of the engine hood 12. Inside the vehicle and above the windshield glass 14 (close to the so-called eye point which is the driver's viewing position), a camera 22 is provided for projection in front of the vehicle in the nighttime. The camera 22 is connected to an image processing unit 48 (FIG. 3). The camera 22 may be a dark-field camera based on an image intensifier tube amplifying the intensity of a dark visible image obtained by receiving X rays of particle beam and converting it into a bright visible image. An illuminometer 70 for detecting the brightness around the vehicle is disposed below the windshield glass 14 and on the front side inside the vehicle 10 (direction shown by arrow FR in FIG. 1). The illuminometer 70 uses an element converting the quantity of light into voltage or electric current, for example, a CdS element. A vehicle speed sensor 66 (FIG. 3) for detecting the speed Sp of vehicle 10 is disposed on the cable of the speedometer (not shown in the figures) inside the vehicle 10.

[0013] As shown in FIG. 2, a steering wheel 26 is disposed inside the vehicle 10. A turn signal lever 28 and a wiper control lever 30 are disposed close to the rotary shaft (not shown in the figure) of the steering wheel 26.

[0014] A light control switch 32 (FIG. 3) mounted on the distal end of turn signal lever 28 is for switching the headlamps 18, 20 between a turn-on position and the turn-off position. The ON/OFF switching is conducted by turning the distal end of turn signal lever 28 about the axis of turn signal lever 28. The headlamps 18, 20 are turned on or off by operating the light control switch 32.

[0015] As shown in FIG. 3, a control unit 50 for controlling the quantity of light of the headlamps 18, 20 comprises a read only memory (ROM) 52, a random access memory (RAM) 54, a central processing unit (CPU) 56, an input port 58, an output port 60, a driving unit 64, and a bus 62, such as a data bus or control bus, for connecting the above-mentioned components. Further, The ROM 52 stores the below-described maps and control program for controlling the headlamps. The input port 58 is connected to the camera 22 via an illuminometer 70, a vehicle speed sensor 66, and an image processing unit 48. The output port 60 is connected to control terminals 67, 69 of voltage setting circuits 66, 68 via the driver 64 and also to the image processing unit 48.

[0016] The bulb 40 of headlamp 18 is connected at one end thereof to the light control switch 32 via the voltage setting circuit 66 and grounded at the other end. The voltage setting circuit 66 sets the voltage supplied to the headlamp. The voltage setting circuit 66 is composed of elements such as FET or transistors and sends the voltage output according to the control signal (voltage value V_H) input to a control terminal 67 from the control unit 50. Therefore, if the light control switch 32 is turned on, the headlamp 18 is ignited with the prescribed brightness corresponding to the voltage value V_H input from the control unit 50.

[0017] Similarly, one end of bulb 41 of headlamp 20 is connected to the light control switch 32 via the voltage setting circuit 68 and the other end thereof is grounded. A control signal (voltage

value V_H) from the control unit 50 is input to the control terminal 69 of voltage setting circuit 68.

[0018] The other vehicle (preceding or oncoming vehicle) recognition processing and computation of the distance between the vehicles in the image processing unit 48 of the present embodiment will be described hereinbelow. The position of each pixel in the image formed by the image signal is specified by coordinates (X_n, Y_n) determined by orthogonal axis X and Y set on the image.

[0019] As shown in FIG. 4(1), in the image 120 which is the image projected by the camera 22, the preceding vehicle 11 is positioned between the white lines 124 on both sides of the lane of road 122 where the vehicle 10 travels. This image 120 is processed in the image processing unit 48.

[0020] First, the white line candidate point extraction processing and linear approximation processing are conducted sequentially, the travel lane of vehicle 10 is detected, and a vehicle recognition region W_P is set.

[0021] In the white line candidate point extraction processing, the candidate points which are assumed to represent the white lines of the lane are extracted. First, a window region W_S is set (see FIG. 4(3)) which has the prescribed width γ assumed to contain the white lines and a point with a large variation of brightness within the window region W_S (the point with a maximum differential value of brightness in the vertical direction) is extracted as a white line candidate point (edge point). The case in which the continuation of this edge point has been found is illustrated by the dot line 132 in FIG. 4(3). In the regions above and below the image 120, the probability of the preceding vehicle being present is low. Therefore, the range between the predetermined upper limit line 128 and lower limit line 130 is used as the processing object region.

[0022] In the subsequent linear approximation processing, the edge points extracted in the white line candidate point extraction processing are linearly approximated by using the Hough conversion and straight lines 134, 136 along the lines assumed as the white lines are found. The region surrounded by the straight lines 134, 136 and the lower limit line 130 is set as the vehicle recognition region W_P (see FIG. 4(4). When the road 122 is curved, the vehicle recognition region W_P with different inclinations of the straight lines 136, 138 found hereinabove is obtained (see FIG. 4(2)).

[0023] Once setting of the vehicle recognition region W_P has been completed, the detection processing is conducted in the below-described manner, the presence of the preceding vehicle 11 in the vehicle recognition region W_P is assessed and when the preceding vehicle 11 is present therein, the distance between the vehicles S_L is calculated.

[0024] First, edge points are detected, similarly to the above-described white line candidate point detection processing, inside the vehicle recognition region W_P and a peak point E_P in the position in which the integrated value obtained by integrating the detected edge points in the lateral direction exceeds the prescribed value is detected (see FIG. 4 and FIG. 5). When there are a plurality of peak points E_P, a peak point position in the lower part on the image (the point with a

6

shorter distance) is selected. The window regions W_R, W_L containing respective both edges of pixel points in the horizontal direction corresponding to the peak points E_P are set (see FIG. 4(6)). A decision is made that the preceding vehicle 11 is present when the continuous points (vertical lines 138R, 138L) in the vertical direction have been detected with good stability inside the window regions W_R, W_L.

[0025] Because the distance S between those detected vertical lines 138R, 138L in the lateral direction corresponds to the vehicle width, the distance S_L between the preceding vehicle 11 and the own vehicle 10 is calculated from the vehicle width and position of peak point E_P. For example, by taking a standard width S_o of a vehicle as a base, it is possible to find a ratio of the distance S to the width of the vehicle detected from the image and to calculate the distance S_L between the vehicles from this ratio. The spacing between the vertical lines 138R, 138L in the lateral direction can be calculated from the difference in representative X coordinates (for example, an average coordinate value or high-frequency coordinate value).

[0026] Further, when no preceding vehicle 11 is detected in the above-described processing, the distance S_L between the vehicles is set to 0. As a result, the value of the distance S_L between he vehicles also contains information demonstrating as to whether or not the preceding vehicle 11 is present in front of the own vehicle 10 based on whether $S_L = 0$ or $S_L > 0$.

[0027] The recognition processing of the oncoming vehicle 11A from the image 120 will be described below. First, after the above-described preceding vehicle recognition processing, a correction value α employed for correction is set so as to contain the found approximation line 132 (of the oncoming vehicle side). Because of a high probability of the oncoming vehicle being positioned close to the approximation line 132 of the oncoming vehicle side, the correction is made by positioning close thereto to prevent the detection of the oncoming vehicle by headlamps from being excluded by the size of the set oncoming vehicle recognition region. The region to the right of the straight line 133 determined by finding the straight line 133 according to the set correction value α (when passing on the left) is set as the oncoming vehicle recognition region W_{P0} (see FIG. 5). In the oncoming vehicle recognition region W_{P0}, the recognition processing of the oncoming vehicle 11A is conducted and the distance S_R between the vehicles is found similarly to the above-described preceding vehicle recognition process, based on the light spot created by the light of the headlamps of oncoming vehicle 11A.

[0028] After the oncoming vehicle recognition region W_{P0} has been set, a region W_{00} may be set which contains a range between the predetermined upper limit line and lower limit line where the probability of oncoming vehicle 11A presence is high and the distance S_R between the vehicles may be found by recognition processing the oncoming vehicle 11A within this region.

[0029] Further, in the above-described example, the road was specified by detecting the white line 124, but it is not necessary to use only the white line 124, and the detection may be also conducted by using a curb stone at the side of road 122. In this case, detection of either the white line or the curb stone can be conducted by changing the detection level of graded image.

[0030] The inventors have conducted a test by causing glare for the driver of an oncoming vehicle

7

(measurement of front view illumination at which the driver feels the glare) with the light of headlamps of the own vehicle 10. The test was conducted with respect to two states: a state in which the two vehicles gradually approached one another while moving on the road (this state will be referred to hereinbelow as a normal approach state) and a state in which the vehicle rapidly approach one another, for example, when the oncoming vehicle appears in an intersection (this state will be referred to hereinbelow as a rapid approach state). For each state, a large number of distances between the vehicle 10 and the oncoming vehicle were set within a range between 25 m and 250 m and the front view illumination of the driver of the oncoming vehicle was measured when the voltage of the headlamps of own vehicle 10 was decreased to a level at which the driver of the oncoming vehicle experienced no glare at each distance between the vehicles. The voltage value of the headlamps of own vehicle 10 corresponding to the front view illumination of the driver of the oncoming vehicle was also measured (those values are not shown in the figures).

[0031] FIG. 7 shows the measurement results relating to a dark road, that is, to a state when it is dark around the vehicle (high illumination intensity). Furthermore, FIG. 8 illustrates the measurement results obtained when it is light around the vehicle (low illumination intensity). In the figures, the distance (units: m) between the own vehicle and the other vehicle is plotted against the abscissa and the forward illumination intensity (unit, lx) of the driver of the oncoming vehicle is plotted against the ordinate. The normal approach state is shown in (1) and the rapid approach state is shown in (2). The relationships of the two types are shown in the same figure. The figure clearly demonstrates that the driver of the oncoming vehicle 11A experiences glare at a lower illumination intensity in the rapid approach state than in the normal approach state.

[0032] As follows from FIG. 7 and FIG. 8, it is possible to set a voltage value of the headlamps of vehicle 10 resulting in a forward illumination intensity at which the driver of oncoming vehicle 100 experiences no glare according to the variation (speed or acceleration) of the distance between the own vehicle 10 and oncoming vehicle 11A and the brightness around the vehicles.

[0033] In the present embodiment, the relationship between the voltage value of the headlamps and the distance between the vehicles is stored as a map 1 with respect to the oncoming vehicle 11A when it is dark around the vehicles (FIG. 7). Further, the relationship between the voltage value of the headlamps and the distance between the vehicles is stored as a map 2 with respect to the oncoming vehicle 11A when it is light around the vehicles (FIG. 8). In each of the maps 1 and 2, the normal approach state is stored as (1) and the rapid approach state is stored as (2).

[0034] It can be assumed that the brightness-induced variations similar to the above-described variations also occur for the preceding vehicle. However, because such variations are stochastically more significant for the oncoming vehicle, the approach state of only the oncoming vehicle may be evaluated, and the preceding vehicle 11 is handled based on a normal approach mode. It goes without saying that the evaluation of approach state may be conducted with respect to the preceding vehicle in the same manner as described hereinabove.

[0035] The operation of the present embodiment will be described below. The light distribution control routing shown in FIG. 6 is executed each prescribed time if the ignition key switch (not shown in the figures) is turned on.

[0036] If the present light distribution control routine is executed, a transition is made to step 202 and a decision is made as to whether or not the headlamps 18, 20 have been turned on by evaluating the ON/OFF state of the light control switch 32. When the headlamps 18, 20 are turned off, the light distribution control is unnecessary (negative decision in step 202). Therefore, the present routine is terminated.

[0037] If the headlamps 18, 20 are turned on (positive decision in step 202), a transition is made to step 204 and, after an image processing initiation signal has been output to the image processing unit 48, the distance S_L between the vehicle 10 and the preceding vehicle 11 and the distance S_R between the vehicle 10 and the oncoming vehicle 11A found in the image processing unit are read out and, at the same time, the illumination intensity (brightness) around the vehicle 10 is read with the illuminometer 70. The explanation of image processing described hereinabove demonstrated that the recognition processing of the preceding vehicle 11 and oncoming vehicle 11A is conducted in the image processing unit 48, and, at the same time, the distance S_L between the vehicles is calculated with respect to the preceding vehicle 11 and the distance S_R between the vehicles is calculated with respect to the oncoming vehicle 11A.

[0038] In the next step 206, the variation dS_R is calculated from the distance S_R to the oncoming vehicle 11A that has been read out and the distance S_R' between the vehicles that has been read out in the previous cycle. This variation dS_R corresponds to the approach speed (relative speed) or approach acceleration (relative acceleration) of oncoming vehicle 11A. If the variation dS_R is calculated, a transition is made to step 208, where the value of variation dS_R is compared with the standard value S_{ST} determined in advance to distinguish the normal approach state from the rapid approach state.

[0039] When $dS_R < S_{ST}$, the normal approach state is recognized and the value of brightness L around the vehicle is compared with the standard value L_0 determined in advance to distinguish the dark state from the light state in the environment where the other vehicle travels. When $L < L_0$, the environment is considered to be dark and in step 212 the voltage value corresponding to the distance between the vehicles is set to voltage value V_H by using the map 1-(1) corresponding to the normal approach state and dark environment. When $L \geq L_0$, the environment is considered to be light and in step 214 the voltage value corresponding to the distance between the vehicles is set to voltage value V_H by using the map 2-(1) corresponding to the normal approach state and light environment. If $dS_R < S_{ST}$, the case in which only the preceding vehicle is present is included in the case of the normal approach state.

[0040] Even slight variations in the distance between the vehicles in the normal approach state can result in significant changes in the voltage set according to the distance between the vehicles, that is, in the brightness of the headlamps (see FIG. 7). In the next step 216, the variation ratio from the presently set voltage value to the voltage value V_H that will be set thereafter is determined. Therefore, if the brightness of headlamps is controlled based on the voltage value V_H and variation ratio in the next step 218, then the brightness will change gradually without rapid changes. As a result, the quantity of light can be changed without causing discomfort for the drivers of the own and other vehicles.

9

[0041] In the next step 218, the voltage of headlamps 18, 20 is controlled by outputting the voltage value V_H that has been set to the voltage setting circuits 66, 68. Thus, in the voltage setting circuits 66, 68, the voltage of a battery BT is changed to the voltage value V_H and supplied to bulbs 40, 41. As a result, the light of headlamps with an illumination intensity corresponding to the normal approach state of the other vehicle with respect to the own vehicle 10 is projected forward.

[0042] On the other hand, when $dS_R \geq S_{ST}$, a rapid approach state is recognized and the routine advances to step 220. In step 220, the brightness L around the own vehicle is compared with the preset standard value L_O. If $L < L_O$, a decision is made that the environment is dark and in step 222 a voltage value corresponding to the distance between the vehicles is set to the voltage value V_H by using the map 1-(2) corresponding to the rapid approach state and dark environment. In the case of $L \geq L_O$, a decision is made that the environment is light and in step 224 a voltage value corresponding to the distance between the vehicles is set to the voltage value V_H by using the map 2-(2) corresponding to the rapid approach state and light environment.

[0043] Therefore, in the next step 218, the voltage value V_H that has been set is output in the voltage set circuits 66, 68 and the voltage of headlamps 18, 20 is controlled. As a result, the light of headlamps with an illumination intensity corresponding to the rapid approach state of the other vehicle with respect to the own vehicle 10 is projected forward.

[0044] Thus, in the present embodiment, the brightness of the headlamps of the own vehicle has been set according to the distance to at least one other vehicle of preceding vehicle and oncoming vehicle and the approach state (including the appearance state) of the other vehicle. Therefore, the headlamp brightness can be set such that no glare is provided at any time to the other vehicle approaching the own vehicle on the road. Moreover, the headlamps of the own vehicle can be operated at an optimum brightness such that no glare is provided to the oncoming vehicle even when the oncoming vehicle unexpectedly appears, for example, in the intersection or the like.

[0045] Furthermore, because the brightness of the headlamps of the own vehicle has been set according to the brightness of environment in which the vehicle travels, the brightness standard at which the driver of the other vehicle experiences glare can be changed and the headlamps of the own vehicle can be operated at an optimum brightness taking into account the effect of the brightness of the environment.

[0046] Further, in the present embodiment, the explanation related to the case in which the approach state of the other vehicle was classified into two states; normal approach state and rapid approach state. The present invention is, however, not limited to such a classification, and a plurality of states, e.g., no less than three states, or a continuously variable state may be handled. Moreover, the preceding vehicle was considered to be in a normal approach state, but the approach state of the preceding vehicle may be also classified into two or more states and the brightness of the headlamps of the own vehicle may be set based on the combination of those states and states of the oncoming vehicle.

[0047] Further, in the above-described embodiment, the quantity of light was detected with an illuminometer. The present invention is, however, not limited to such an embodiment, and the quantity of light may be computed from the brightness signal obtained from a photographic equipment, for example, a camera, or by using a measurement device such as a spot meter or the like.

[0048] Moreover, in the above-described embodiment, the explanation related to the case in which the quantity of light of the headlamps was changed. The present invention is, however, not limited to such an embodiment and can be applied to the headlamp units for automobiles equipped with headlamps with a variable optical axis or illumination range. In such cases, the conditions may be set based on the standard of optical axis or illumination ranges which cause no glare in the other vehicle. Furthermore, the above-described headlamps with a variable quantity of light may be provided separately in addition to the headlamps with a fixed quantity of light that are usually used.

[0049] Further, in the present embodiment the other vehicle was detected from the image picked up in front of the vehicle. The present invention is, however, not limited to such an embodiment, and the other vehicle may be also detected using a distance measuring device.

[0050]

[Effect of the Invention].As described hereinabove, in accordance with the invention disclosed in claim 1, at least one parameter of illumination direction, illumination range, and brightness of the headlamps is controlled based on the movement state of the other vehicle traveling in front of the own vehicle. Therefore, the headlamps can be operated so that no glare is provided that corresponds to the approach state of the other vehicle which approaches the own vehicle when traveling on the road or entering the intersection.

[0051] In accordance with the invention disclosed in claim 2, the brightness around the other vehicle traveling in front of the own vehicle is detected and at least one parameter from illumination direction, illumination range, and brightness of the headlamp is controlled based on the detected brightness and movement state. Therefore, the headlamp of the own vehicle can be operated at the optimum brightness taking into account the effect of the brightness of environment in which the own vehicle and other vehicle are driven.

[Brief Description of the Drawings]

FIG. 1 is a perspective view illustrating the front part of a vehicle, as viewed at an angle from the front of the vehicle.

FIG. 2 is a perspective view illustrating the front part of a vehicle, as viewed at an angle from the occupant's seat of he vehicle.

FIG. 3 is a schematic structural view illustrating a control unit and peripheral components of a headlamp that can be used in the headlamp unit for a vehicle in accordance with the present invention.

FIG. 4 is an image view for explaining the process for recognizing a preceding vehicle

based on the image output of a camera.

FIG. 5 is an image view illustrating the oncoming vehicle recognition region.

FIG. 6 is a flowchart illustrating the main routine of light distribution control of the present embodiment.

FIG. 7 is a characteristic chart illustrating the relationship between the driver front illumination intensity of the other vehicle, the distance between the vehicles, and the headlamp voltage value in a dark atmosphere.

FIG. 8 is a characteristic chart illustrating the relationship between the driver front illumination intensity of the other vehicle, the distance between the vehicles, and the headlamp voltage value in a light environment.

[Legends]

18   HEADLAMP (HEADLAMP)
22   CAMERA
48   IMAGE PROCESSING UNIT (MEANS FOR DETECTING DISTANCE BETWEEN
      THE VEHICLES)
50   CONTROL UNIT (CONTROL MEANS)
70   ILLUMINOMETER (BRIGHTNESS DETECTION MEANS)

FIG. 1

18   HEADLAMP (HEADLAMP)
22   CAMERA

FIG. 3

48   IMAGE PROCESSING UNIT (MEANS FOR DETECTING DISTANCE BETWEEN
      THE VEHICLES)
50   CONTROL UNIT (CONTROL MEANS)
58   INPUT PORT
60   OUTPUT PORT
64   DRIVING UNIT
70   ILLUMINOMETER (BRIGHTNESS DETECTION MEANS)

FIG. 4

(5)   INTEGRAL VALUE

FIG. 6

START
202   IS HEADLAMP ON?
204   SURROUNDING BRIGHTNESS L AND DISTANCE BETWEEN VEHICLES S_R, S_L
      ARE READ
206   CALCULATION OF VARIATION QUANTITY dS_R
212   NORMAL APPROACH – DARK : MAP 1-(1)
214   NORMAL APPROACH – LIGHT : MAP 2-(1)
216   VARIATION RATE IS DETERMINED
218   VOLTAGE CONTROL
222   RAPID APPROACH – DARK : MAP 1-(2)
224   RAPID APPROACH – LIGHT : MAP 2-(2)
END

FIG. 7

INTENSITY OF FORWARD ILLUMINATION (lx)
DISTANCE TO ONCOMING VEHICLE (m)
MAP 1

FIG. 8

INTENSITY OF FORWARD ILLUMINATION (lx)
DISTANCE TO ONCOMING VEHICLE (m)
MAP 12

Continuation from the front page

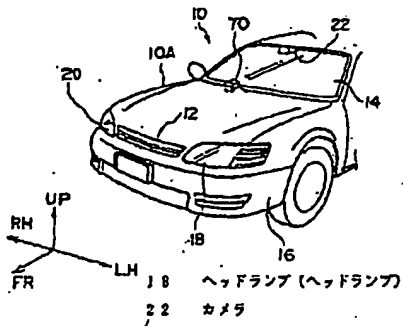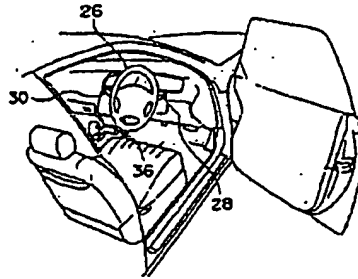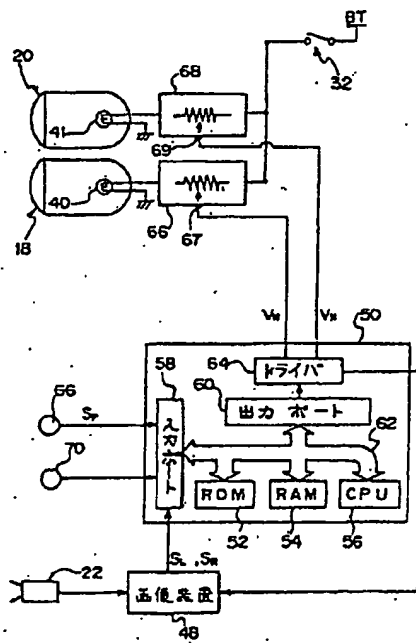| (51) Int. Cl.^{6}	Id. No.	Office Reg. No.	FI	Techn. Ind. Field.
H04 N 7/18	K			

特開平7−69125

【図1】

【図2】

18 ヘッドランプ（ヘッドランプ）
22 カメラ

【図3】

48 画像処理装置（車間距離検出手段）
50 制御装置（制御手段）
70 照度計（明るさ検出手段）

【図4】

【図6】

スタート

ヘッドアップオン？ ──202

周辺の明るさL 読取
車間距離$S_R S_L$ ──204

変化量dS_R 演算 ──206

$dS_R < S_{BT}$ ──208 220

$L < L_o$ ──212 210

$L < L_o$ ──220

通常接近・暗
マップ1−(1)

通常接近・明
マップ2−(1) ──214

急接近・暗
マップ1−(2) ──222

急接近・明
マップ2−(2) ──224

変動率決定 ──216

電圧制御 ──218

エンド

【図7】

反応時間

(1)

(2)

マップ1

100 200
対向車両との車間距離 (m)

【図8】

反応時間

(1)

(2)

マップ2

100 200
対向車両との車間距離 (m)
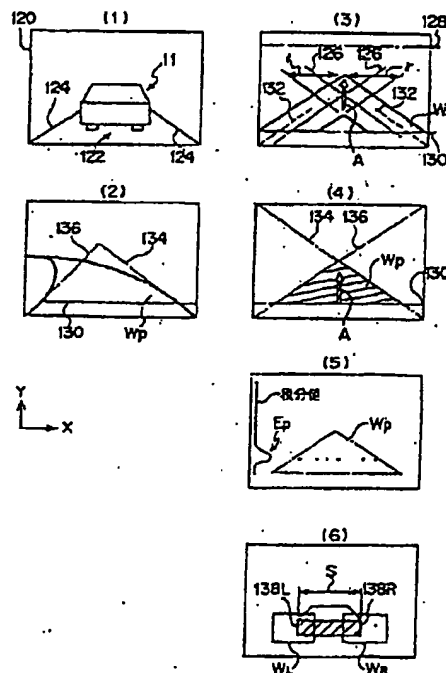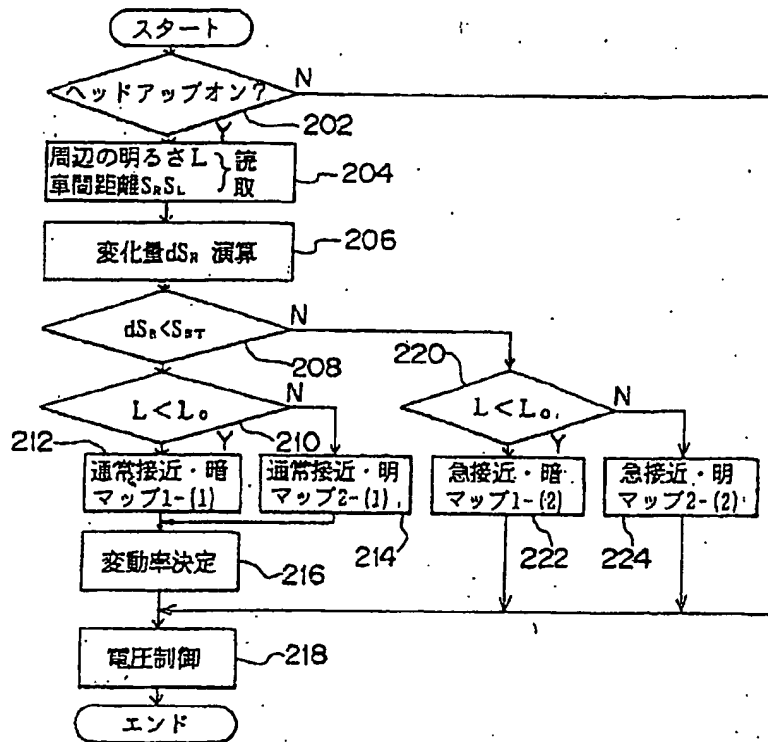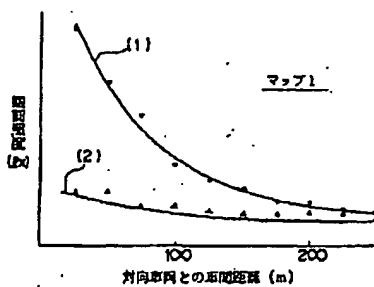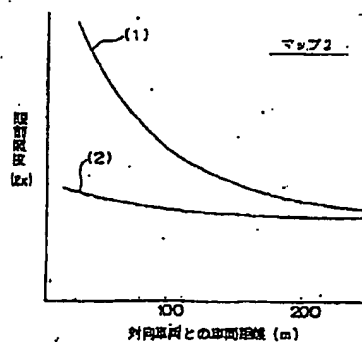
フロントページの続き

(51)Int.Cl.⁶	識別記号	庁内整理番号	FI	技術表示箇所
H04N　7/18			K	

(51) Int.Cl.^{6}	Identification Number	Intraoffice Reference Number	F1	Field of Technology Indication
B60Q 1/14		A		
		F		
		H		
1/08				
F21M 3/18				

(71) Applicant: 000003207
                     Toyota Motor Corp.
                     1, Toyota-machi, Toyota-shi, Aichi-ken
(72) Inventor: Takagi Makoto
                     1, Toyota-machi, Toyota-shi, Aichi-ken
                     c/o Toyota Motor Corp.
(72) Inventor: Satonaka Hisashi
                     1, Toyota-machi, Toyota-shi, Aichi-ken
                     c/o Toyota Motor Corp.
(74) Agent: Patent Attorney, Atsushi Nakashima (and two more agents)

(54) [Title of the Invention] HEADLAMP DEVICE FOR VEHICLE

(570 [Abstract]

[Object] To emit light of optimum brightness to be viewed by the driver, without dazzling the driver of the other vehicle.

[Structure] The distance S_L between the vehicles (vehicle ahead), distance S_R between the vehicles (oncoming vehicle), and brightness L of the environment are read and variation dS_R of distance S_R is calculated (202-206). When the variation dS_R is small (208) and the environment is dark, the voltage value is set from the dark map for a usual approach mode, when the environment is bright, the voltage value is set from the bright mode for a usual approach mode (210-214), and the lamp brightness is controlled correspondingly to the set voltage values and

variation rate (216, 218). When the variation dS_R is large (220) and the environment is dark, the voltage value is set from the dark map for a rapid approach mode (222), when the environment is bright, the voltage value is set from the bright mode for a rapid approach mode (224), and the lamp brightness is controlled correspondingly to the set voltage values (218). Therefore, the headlamp light corresponding to the approach state of the other vehicle and brightness of the environment is emitted forward.

[Patent Claims]

[Claim 1] A headlamp device for a vehicle comprising:
a headlamp with a variable illumination state represented by at least one of illumination direction, illumination range, and brightness;
movement state detection means for detecting a movement state of another vehicle traveling in front of an own vehicle; and
control means for controlling at least one of the illumination direction, illumination range, and brightness of said headlamp based on the detected movement state.

[Claim 2] A headlamp device for a vehicle comprising:
a headlamp with a variable illumination state represented by at least one of illumination direction, illumination range, and brightness;
movement state detection means for detecting a movement state of another vehicle traveling in front of an own vehicle;
brightness detection means for detecting brightness around said another vehicle; and
control means for controlling at least one of the illumination direction, illumination range, and brightness of said headlamp based on the detected brightness and movement state.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Use] The present invention relates to a headlamp device for a vehicle, and more particularly to a headlamp device for a vehicle which controls light distribution of headlamps for illuminating space in front of the vehicle.

[0002]

[Prior Art] Vehicles are equipped with headlamps with switchable light distribution (the so-called low beam and high beam) that can be switched between a state with far-range illumination with a large quantity of light and a state with close-range illumination with a small quantity of light in order to improve forward visibility for a driver, e.g., at night. The headlamps are fixed almost at the front end of the vehicle and illuminate a comparatively wide preset range.

[0003] On a usual road where the vehicle equipped with the headlamps travels, this vehicle is

2

sometimes present together with an oncoming vehicle located in front of the vehicle. When an oncoming vehicle is present in front of the vehicle and the headlamps are in a far-range illumination state, a large quantity of light is illuminated toward the oncoming vehicle and the driver of the oncoming vehicle is dazzled. For this reason, there is a light quantity control unit (Japanese Utility Model Application Laid-open No. S63-129641) that detects the quantity of light around the own vehicle, including the light from the headlamps of the oncoming vehicle, with a sensor and controls the quantity of light of the headlamps of the own vehicle based on the detected values.

[0004]

[Problems Addressed by the Invention] However, dazzling of the driver of the other vehicle such as a vehicle ahead or an oncoming vehicle depends on the manner in which the own vehicle and the other vehicle approach or appear. For example, when the oncoming vehicle approaches the own vehicle in a usual approach mode realized when the two vehicle travel on the road, that is, in a gradual approach mode, and in a rapid approach mode in which the oncoming vehicle appears at the intersection with a large number of obstacles, the degree of dazzling is higher in the case of rapid approach even if the same quantity of light is illuminated and the distance between the vehicles is the same. Therefore, when the quantity of light of the headlamps of the own vehicle is unconditionally controlled by the quantity of light of the headlamps of the oncoming vehicle that is emitted toward the own vehicle, as in the above-described light quantity control unit, the driver of the oncoming vehicle is sometimes dazzled.

[0005] Furthermore, the brightness of the headlamps of the own vehicle at which the driver of the other vehicle is dazzled depends on the brightness of the environment, e.g., a road where the vehicles travel. For example, the brightness level that causes no dazzling in a city where the quantity of light from street lamps or buildings is large can cause dazzling on a road with a small number of surrounding objects that scatter light. Therefore, in certain environments the driver of the other vehicle can be glared by the light from the headlamps of the own vehicle.

[0006] With the foregoing in view, it is an object of the present invention to provide a headlamp device for a vehicle that can emit light of optimum brightness to be viewed by the driver, without dazzling the driver of the other vehicle.

[0007]

[Means to Resolve the Problems] In order to attain the above-described object, the invention of claim 1 provides a headlamp device for a vehicle comprising a headlamp with a variable illumination state represented by at least one of illumination direction, illumination range, and brightness, movement state detection means for detecting a movement state of another vehicle traveling in front of an own vehicle, and control means for controlling at least one of the illumination direction, illumination range, and brightness of the headlamp based on the detected movement state.

[0008] The invention of claim 2 provides a headlamp device for a vehicle comprising a

3

headlamp with a variable illumination state represented by at least one of an illumination direction, illumination range, and brightness, movement state detection means for detecting a movement state of another vehicle traveling in front of an own vehicle, brightness detection means for detecting brightness around the other vehicle, and control means for controlling at least one of the illumination direction, illumination range, and brightness of the headlamp based on the detected brightness and movement state.

[0009]

[Operation] The headlamp device for a vehicle of the invention described in claim 1 comprises a headlamp with a variable illumination state represented by at least one of illumination direction, illumination range, and brightness. The movement state detection means detects the movement state of another vehicle traveling in front of the own vehicle. The other vehicle can be a vehicle ahead that travels in front of the own vehicle in the same direction as the own vehicle or an oncoming vehicle that travels in the passing direction, that is, in the direction opposite that of the own vehicle. The movement state can be a state in which the other vehicle approaches or gets farther. In particular, in a state where the oncoming vehicle approaches, the oncoming vehicle can travel in the usual passing direction or it can appear suddenly as in the case of entering the road where the own vehicle travels, e.g., at an intersection. The control means controls at least one of the illumination direction, illumination range, and brightness of the headlamp based on the detected movement state. Therefore, because the illumination state of the headlamps is changed according to the movement state of the other vehicle, it is possible to set the illumination state of the headlamps that is optimum for the other vehicle movement state: approaching, moving away, and appearing suddenly.

[0010] The headlamp device for a vehicle of the invention described in claim 2 further comprises brightness detection means for detecting brightness around the other vehicle. Brightness around the other vehicle can be detected form the value of quantity of light obtained when the prescribed range where the other vehicle is present is picked up and also can be estimated from the detected value obtained in detecting the brightness around the own vehicle. The control means controls the brightness of the headlamp based on the detected brightness and movement state. As a result, the headlamps of the own vehicle can be turned on at the optimum brightness that takes into account the effect of glare on the driver of the other vehicle created by the brightness of the environment where the own vehicle and other vehicle travel.

[0011]

[Embodiments] The embodiments of the present invention will be described below in greater detail with reference to the appended drawings. In the below-described embodiment, the headlamp device for a vehicle in accordance with the present invention is applied to a control unit of a headlamp for controlling light distribution of the headlamp installed in front section of the vehicle. The symbol FR in the vehicle denotes the direction forward of the vehicle, symbol UP denotes the direction upward of the vehicle, symbol LH denotes the direction leftward of the vehicle, and symbol RH denotes the direction rightward of the vehicle.

4

[0012] As shown in FIG. 1, an engine hood 12 is disposed in the upper surface section of a front body 10A of a vehicle 10, and a pair of left and right (both end sections in the widthwise direction of the vehicle) headlamps 18, 20 are installed above the front bumper 16 fixed to both end sections in the widthwise direction of the vehicle in the front end section of the front body 10A. Furthermore, a windshield glass 14 is provided in the vicinity of the rear end section of the engine hood 12. A camera 22 for picking up images in front of the vehicle at night is disposed above he windshield glass 14 and inside the vehicle 10 (in the position viewable by the driver, that is, close to the so-called eye point). This camera 22 is connected to an image processing unit 48 (FIG. 3). A camera for dark viewing based on an image intensifier tube for multiplying the intensity of a dark visible image obtained by receiving X rays of particle waves and converting them into a bright visible image may be used as the camera 22. An illumination meter 70 for detecting the brightness around the vehicle is disposed below the windshield glass 14 and in the front section inside the vehicle 10 (FR direction shown by an arrow in FIG. 1). The illumination meter 70 uses an element, e.g. CdS, for converting the quantity of light into voltage or current. Furthermore, vehicle speed sensor 66 (see FIG. 3) for detecting the speed Sp of the vehicle 10 is installed in the cable of the speedometer (not shown in the figure) located inside the vehicle 10.

[0013] As shown in FIG. 2, a steering wheel 26 is disposed inside the vehicle 10. A turn signal lever 28 and a wiper control lever 30 are disposed in the vicinity of the rotation shaft (not shown in the figure) of the steering wheel 26.

[0014] A light control switch 32 (FIG. 3) attached to the distal end section of the turn signal lever 28 is a switch for turning on and off the headlamps 18, 20 and for indicating the state of the headlamps. The switch is turned on and off if the distal end section of the turn signal lever 28 is rotated about the axis of the turn signal lever 28. The headlamps 18, 20 are turned on or off by turning on the light control switch 32.

[0015] As shown in FIG. 3, a control unit 50 for controlling the quantity of light of the headlamps 18, 20 comprises a read only memory (ROM) 52, a random access memory (RAM) 54, a central processing unit (CPU) 56, an input port 58, an output port 60, a driver 64 and a bus such as a data bus and control bus for connecting the aforementioned units. The ROM 52 stores the below-described map and control program for executing the headlamp control. The illumination meter 70, vehicle speed sensor 66, and camera 22 (via the image processing unit 48) are connected to the input port 58. The output port 60 is connected to control terminals 67, 69 of the voltage setting circuits 66, 68 via a driver 64 and also connected to the image processing unit 48.

[0016] A bulb 40 of the headlamp 18 is connected by one terminal thereof to the light control switch 32 via the voltage setting circuit 66 and is grounded by the other terminal thereof. The voltage setting circuit 66 sets the voltage supplied to the headlamp 18. The voltage setting circuit 66 is composed of elements such as FET or transistors and sets a voltage outputted in response to a control signal (voltage value VH) inputted from the control unit 50 to a control terminal 67. Therefore, if the light control switch 32 is turned on, the headlamp 18 is turned on at the prescribed brightness corresponding to the voltage value V_H inputted from the control unit 50.

5

[0017] Similarly, a bulb 41 of the headlamp 20 is connected by one terminal thereof to the light control switch 32 via the voltage setting circuit 68 and is grounded by the other terminal thereof. A control terminal 69 of the voltage setting circuit 68 is so connected that a control signal (voltage value V_H) is inputted thereto from the control unit 50.

[0018] Recognition processing of the other vehicle (vehicle ahead or oncoming vehicle) and computational processing of the distance between the vehicles in the image processing unit of the present embodiment will be described below. The position of each pixel on the image formed by the image signals is specified by the coordinates (Xn, Yn) in the coordination system determined by the orthogonal X axis and Y axis set on the image.

[0019] As shown in FIG. 4(1), in an image 120, which is an image picked up with the camera 22, a vehicle 11 ahead is positioned between white lines 124 located on both sides of a lane of a road 122 where the vehicle 10 travels. The image 120 is processed in the image processing unit 48.

[0020] First, as described hereinabove, the white line candidate point extraction processing and linear approximation processing are successively conducted, the traveling lane of the vehicle 10 is detected, and a vehicle recognition region W_P is then set.

[0021] In the white line candidate point extraction processing, the candidate points that are assumed as the white lines of the lane are extracted. First, a wind region W_S having the prescribed width γ, which is supposed to include the white lines, is set (see FIG. 4(3)), and points with a large variation of brightness inside this wind region W_S (maximum points of the differential values of brightness in the vertical direction) are extracted as a white line candidate points (edge point). A white line 132 in FIG. 4(3) illustrates the case where the continuation of the edge points was found. Because of a low probability of the presence of the vehicle 11 ahead in the regions above and below the image 120, the range between an upper limit line 128 and a lower limit line 130 that were set in advance is used as the processing object region.

[0022] In the subsequent linear approximation processing, the edge points extracted in the white line candidate point extraction processing is linearly approximated by using the Hough transformation, and straight lines 134, 136 along the lines that are supposed to be white lines are found. The region bounded by the straight lines 134, 136 and lower limit line 130 are set as the vehicle recognition region W_P (see FIG. 4(4). When the road 122 is a curved road, a vehicle recognition region W_P having a gradient difference of the straight lines 136, 138 found hereinabove is obtained (see FIG. 4(2)).

[0023] After the setting of the vehicle recognition region W_P has been completed, the detection processing is conducted in the below-described manner to determine the presence of the vehicle 11 ahead in the vehicle recognition region W_P that was thus set, and the distance S_L between the vehicles is calculated when the vehicle 11 ahead is found to be present.

[0024] First, in the vehicle recognition region W_P, the edge points are detected in a manner similar to that of the above-described white line candidate point detection processing, and a peak point E_P of the position where the integral value obtained by integrating the detected edge points

6

in the lateral direction exceeds a present value is detected (see FIG. 4(5)). When there are a plurality of peak points E_P, a peak point E_P (point with a smaller distance) positioned below on the image is selected. The wind regions W_R, W_L comprising both ends of the pixel points in the horizontal direction corresponding to this peak point E_P are set (see FIG. 4(6)). When continuous points (vertical lines 138R, 138L) in the vertical direction are detected with good stability inside the wind regions W_R, W_L, the vehicle 11 ahead is determined to be present.

[0025] Because the distance S between the detected vertical lines 138R, 138L in the transverse direction corresponds to the vehicle width, the vehicle-to-vehicle distance S_L between the vehicle 11 ahead and the own vehicle 10 is calculated from the vehicle width and the position of peak point E_P. For example, it is possible to find the ratio of the distance S to the vehicle width detected from the image by using the standard vehicle width So as a reference and to calculate the distance S_L between the vehicles from this ratio. The distance between the vertical lines 138R, 138L in the transverse direction can be calculated from the difference between the representative X coordinates (for example, average coordinate values or coordinate values with a high occurrence ratio) of the vertical lines 138R, 138L.

[0026] When the vehicle 11 ahead is absent, the distance S_L between the vehicles is set as zero. As a result, the value of the distance S_L between the vehicles also includes information demonstrating whether or not the vehicle 11 ahead is present in front of the vehicle 10 based on whether $S_L = 0$ or $S_L > 0$.

[0027] The recognition processing of the oncoming vehicle 11A from the image 120 will be explained below. First, a correction quantity α for conducting correction so as to include the found approximated straight line 132 (oncoming vehicle side) is set after the above-described recognition processing of the vehicle ahead. Because the probability of the oncoming vehicle being positioned close to the approximated straight lines 132 on the side of the oncoming vehicle is high, this correction is conducted to obtain a position in the vicinity so as to prevent the detection, e.g., of the headlamps of the oncoming vehicle from being excluded due to the size of the oncoming vehicle recognition region that will be set. The right (when driving on the left side) of the straight lines 133 found by finding the straight line 133 correspondingly to the correction quantity α that was thus set is set as the oncoming vehicle recognition region W_{P0} (see FIG. 5). In the oncoming vehicle recognition region W_{P0}, the oncoming vehicle 11A is recognition processed and the distance S_R between the vehicles is found similarly to the above-described recognition processing of the vehicle ahead based on the light spot produced by the light of the headlamp of the oncoming vehicle 11A.

[0028] After the above-mentioned oncoming vehicle recognition region W_{P0} has been set, a region W_{00} comprising a range between the upper limit line and lower limit line that was established in advance and has a high presence probability of the oncoming vehicle 11A may be set and the distance S_R between the vehicles may be also found by conducting the recognition processing of the oncoming vehicle 11A in this region W_{00}.

[0029] Furthermore, in the explanation above, the road was specified by detecting the white line

124, but the detection may be also conducted by the curbstone formed at the side of the road 122, rather than by using only the white line 124. In this case, both the white line and the curbstone may be detected by changing the detection level of graded images.

[0030] The inventors have conducted a test by causing glare to the driver of an oncoming vehicle with the light of the headlamps of the own vehicle 10 (forward illumination at which the driver was dazzled was measured). The test was conducted with respect to two states; a state of gradual approach that is realized when a vehicle travels along the road (referred to hereinbelow as a usual approach state) and a state of rapid approach in which an oncoming vehicle appears at the intersection with a large number of obstacles (referred to hereinbelow as a rapid approach state). In the test, a large number of distances between the vehicle 10 and the oncoming vehicle were determined between 25 m and 250 m, and the forward illumination of the driver of the oncoming vehicle at the time when the voltage of the headlamp of the vehicle 10 was decreased to a level at which the dazzling feeling of the driver of the oncoming vehicle disappeared was measured for each distance between the vehicles. Furthermore, the voltage values of the headlamps of the vehicle 10 corresponding to the forward illumination of the driver of the oncoming vehicle was also measured (the results are not shown in the figure).

[0031] FIG. 7 shows the measurement results relating to a dark road, that is, to a state where the vehicles are in a dark environment (degree of illumination is high). FIG. 8 shows the measurement example relating to a state where the vehicles are in a bright environment (degree of illumination is low). In the figures, the distance between the own vehicle and the other vehicle (units: m) is plotted against the abscissa, and the forward degree of illumination (units: lx) of the driver of the oncoming vehicle is plotted against the ordinate. The usual approach state is shown in (1) and the rapid approach state is shown in (2) thereby presenting the relationship between the two in the same drawing. The figures demonstrate that the driver of the oncoming vehicle 11A is dazzled at a lower degree of illumination in the rapid approach state than in the usual approach state.

[0032] As follows from FIG. 7 and FIG. 8, the voltage value of the headlamps of the own vehicle 10 providing for the forward degree of illumination at which the driver of the oncoming vehicle 11A is not dazzled can be determined correspondingly to the variation (speed or acceleration) of the distance between the vehicle 10 and the oncoming vehicle 11A.

[0033] In the present embodiment, the relationship between the distance between the vehicles and the voltage of the headlamps is stored as a map 1 for the oncoming vehicle 11A in a state with a dark environment (FIG. 7). Furthermore, the relationship between the distance between the vehicles and the voltage of the headlamps is stored as a map 2 for the oncoming vehicle 11A in a state with a bright environment (FIG. 8). In each map 1, 2, the usual approach state is stored as (1) and the rapid approach state is stored as (2).

[0034] Similar changes caused by the brightness can be also assumed for the vehicle 11 ahead, but because the probability is higher for the oncoming vehicle, the approach state of only the oncoming vehicle may be judged and the vehicle 11 ahead is considered to be in the usual approach state. It goes without saying that the approach states may be also judged with respect to

8

the vehicle ahead in the same manner as described above.

[0035] The operation of the present embodiment will be described hereinabove. If an ignition key switch (not shown in the figures) is switched on, a light distribution control routine shown in FIG. 6 is executed for each prescribed interval.

[0036] If the light distribution control routine is executed, the routine advances to step 202, and whether or not the headlamps 18, 20 are on is determined by determining the ON/OFF state of the light control switch 32. When the headlamps 18, 20 are off, the light distribution control is not required (negative answer in step 202) and the routine is ended.

[0037] If the headlamps 18, 20 are switched on (positive judgment in step 202), the routine proceeds to step 204 and an image processing start signal is outputted to the image processing unit 48. Then, the distance S_L between the vehicle 10 and the vehicle 11 ahead and the distance S_R between the vehicle 10 and the oncoming vehicle that were found in the image processing unit 48 are read. In addition, the illumination degree (brightness) L around the vehicle 10 is read with the illumination meter 70. In the image processing unit 48, as was described in the explanation of image processing, the recognition processing of the vehicle 11 ahead and the oncoming vehicle 11A is conducted and the distance S_L relating to the vehicle 11 ahead and the distance S_R relating to the oncoming vehicle 11A are calculated.

[0038] In the next step 206, the variation dS_R is calculated from the distance SRto the oncoming vehicle 11A that was read out and the distance S_R' that was read out in the previous cycle. This variation dS_R corresponds to the approach speed (relative speed) or approach acceleration (relative acceleration) of the oncoming vehicle 11A. Once the variation dS_R has been calculated, the routine advances to step 208 and the variation dS_R and a standard value S_{ST} determined in advance to distinguish between the usual approach state and rapid approach state are compared.

[0039] When $dS_R < S_{ST}$, a decision is made that the usual approach state is realized, and in step 210 the brightness L around the own vehicle and the standard value Lo determined in advance for distinguishing between dark and bright environments where the other vehicle travels are compared. When L < Lo, the environment is determined to be dark, and in step 212 the voltage value corresponding to the distance between the vehicles is set to the voltage value V_H by using the map 1-(1) corresponding to the usual approach state and a dark environment. When L ≥ Lo, the environment is determined to be bright, and in step 214 the voltage value corresponding to the distance between the vehicles is set to the voltage value V_H by using the map 2-(1) corresponding to the usual approach state and a bright environment. The case of $dS_R < S_{ST}$ and a usual approach state also includes the case where only the vehicle ahead is present.

[0040] In the case of a usual approach state, the voltage value, that is, the brightness of the headlamps, determined according to the distance between the vehicles sometimes changes significantly even when the change in the distance between the vehicles is very small (see FIG. 7). Accordingly, in the next step 216, the variation ratio from the voltage value that has been set to the voltage value V_H that will be set hereafter is determined. Therefore, if the brightness of the headlamp is controlled from the voltage value V_H and variation ratio in the next step 218, the

9

brightness changes gradually without rapid fluctuations. As a result, the quantity of light can be changed without creating unpleasant feelings for the drivers of both vehicles.

[0041] In the next step 218, the voltage of the headlamps 18, 20 is controlled by outputting the voltage value V_h, which was set, to the voltage setting circuits 66, 68. Thus, in the voltage setting circuits 66, 68, the voltage of a battery BT is changed to the voltage value V_H and supplied to the bulbs 40, 41. As a result, the light of headlamps is illuminated forward with a degree of illumination corresponding to the usual approach state of the other vehicle to the own vehicle 10.

[0042] On the other hand, when $dS_R \geq S_{ST}$, a decision is made that the rapid approach state is realized, and the routine proceeds to step 220. In step 210, the brightness L around the own vehicle and the standard value Lo determined in advance are compared. When L < Lo, the environment is determined to be dark, and in step 222 the voltage value corresponding to the distance between the vehicles is set to the voltage value V_H by using the map 1-(2) corresponding to the rapid approach state and a dark environment. When L ≥ Lo, the environment is determined to be bright, and in step 224 the voltage value corresponding to the distance between the vehicles is set to the voltage value V_H by using the map 2-(2) corresponding to the rapid approach state and a bright environment.

[0043] Therefore, in the next step 218, the voltage of the headlamps 18, 20 is controlled by outputting the voltage value V_h, which was set, to the voltage setting circuits 66, 68. As a result, the light of headlamps is illuminated forward with a degree of illumination corresponding to the usual approach state of the other vehicle to the own vehicle 10.

[0044] Thus, in the present embodiment, the brightness of the headlamps of the own vehicle is determined correspondingly to the distance to at least one other vehicle, which is selected from the vehicle ahead and the oncoming vehicle, and the approach state (including the appearance state) of the other vehicle. Therefore, the brightness of the headlamps can be set so as to avoid causing glare to the other vehicle approaching the own vehicle in a regular manner on the road. Furthermore, even in the case where the oncoming vehicle unexpectedly appears, e.g., on the intersection, the headlamps of the own vehicle can be turned on at the optimum brightness such that causes no glare to the oncoming vehicle.

[0045] Furthermore, because the brightness of the headlamps of the own vehicle is determined according to the brightness of the environment where the vehicle travels, the brightness level at which the driver of the other vehicle is dazzled can be changed and the headlamps of the own vehicle can be turned on at the optimum brightness that takes into account the brightness of the environment.

[0046] Furthermore, in the present embodiment, the case was explained in which the approach state of the oncoming vehicle was classified into a usual approach state and a rapid approach state, but the present invention is not limited to this case and three or more approach states or a continuous approach mode may be considered. Furthermore, the vehicle ahead was considered to be in a usual approach state, but the approach state of the vehicle ahead may be classified into

two or more states and the brightness of the headlamps of the own vehicle may be determined based on the combination with the oncoming vehicle.

[0047] Furthermore, in the present embodiment the quantity of light was detected with an illumination meter, but the present invention is not limited to this configuration and the quantity of light may be found by calculating from the luminance signal from an image pickup device such as a camera. Furthermore, a measuring device such as a spot meter may be also used.

[0048] Furthermore, in the present embodiment, the case was explained where the quantity of light of the headlamps was changed, but the present invention is not limited to this configuration and the application to a front illumination unit for vehicles comprising headlamps with a variable optical axis of illumination range is also possible. In this case, the conditions may be determined by using the optical axis or irradiation range causing no glare to the other vehicle as a reference. Furthermore, the above-described headlamps with a variable quantity of light may be installed separately in addition to the headlamps with a fixed quantity of light that are usually used.

[0049] Moreover, in the above-described embodiment, the other vehicle was detected from the image picked up in front of the own vehicle, but the present invention is not limited to this configuration and the other vehicle may be detected by using a distance measurements device such as a range meter.

[0050] As described hereinabove, with the invention described in claim 1, at least one of illumination direction, illumination range, and brightness of the headlamps is controlled based on the movement state of the other vehicle that travels in front of the own vehicle. The resultant effect is that when the other vehicle travels along the road or enters the intersection, the headlamps can be turned on in a state that corresponds to the approach state of the approaching other vehicle, without producing any glare.

[0051] As described hereinabove, with the invention described in claim 2, at least one of illumination direction, illumination range, and brightness of the headlamps is controlled based on the movement direction and brightness detected by detecting the brightness around the other vehicle that travels in front of the own vehicle. The resultant effect is that the headlamps of the own vehicle can be turned on at an optimum brightness taking into account the effect of the brightness of the environment where the own vehicle and other vehicle travel.

[Brief Description of the Drawings]

FIG. 1 is a perspective view as viewed from the inclined direction in front of the vehicle illustrating the front part of the vehicle.

FIG. 2 is a perspective view as viewed from an angle from behind a driver's seat of the vehicle illustrating the front part of the vehicle.

FIG. 3 is a schematic structural view illustrating a control unit and headlamp periphery where the headlamp device for a vehicle in accordance with the present invention can be employed.

FIG. 4 is an image diagram for explaining the process of recognizing a vehicle ahead

based on the image outputted by a camera.

FIG. 5 is an image diagram illustrating the oncoming vehicle recognition region.

FIG. 6 is a flowchart illustrating the main routine of light distribution control of the present embodiment.

FIG. 7 is a characteristic diagram illustrating the relationship between a degree of illumination in front of a driver of the other vehicle as well as a headlamp voltage value and the distance between the vehicles in a dark environment.

FIG. 8 is a characteristic diagram illustrating the relationship between a degree of illumination in front of a driver of the other vehicle as well as a headlamp voltage value and the distance between the vehicles in a bright environment.

[Keys]

18	headlamp (headlamp)
22	camera
48	image processing unit (means for detecting the distance between the vehicles)
50	control unit (control means)
70	illumination meter (brightness detection means)

FIG. 1

18   HEADLAMP (HEADLAMP)
22   CAMERA

FIG. 3

48   IMAGE PROCESSING UNIT (MEANS FOR DETECTING THE DISTANCE
        BETWEEN THE VEHICLES)
50   CONTROL UNIT (CONTROL MEANS)
58   INPUT PORT
60   OUTPUT PORT
64   DRIVER
70   ILLUMINATION METER (BRIGHTNESS DETECTION MEANS)

FIG. 6

START
202   IS HEADLAMP ON?
204   BRIGHTNESS L OF ENVIRONMENT AND DISTANCES S_R, S_L BETWEEN THE
        VEHICLES ARE READ
206   VARIATION dS_R IS CALCULATED
210   USUAL APPROACH, BRIGHT MAP 2-(1)
212   USUAL APPROACH, DARK MAP 1-(1)
216   VARIATION RATE IS DETERMINED
218   VOLTAGE IS CONTROLLED
222   RAPID APPROACH, DARK MAP 1-(2)
224   RAPID APPROACH, BRIGHT MAP 2-(2)
END

FIG. 7

DEGREE OF FORWARD ILLUMINATION (lx)
DISTANCE TO ONCOMING VEHICLE (m)
MAP 1

FIG. 8

DEGREE OF FORWARD ILLUMINATION (lx)
DISTANCE TO ONCOMING VEHICLE (m)
MAP 2

Continued from the first page

(51) Int.Cl.^{6}	Identification Number	Intraoffice Reference Number	F1	Field of Technology Indication
H04N 7/18		K		

14

VERIFICATION OF A TRANSLATION

I, the below named translator, hereby declare that:

My name and post office address are as stated below:
Boris Zhupanov, 5097 Glenaire Drive, Dublin, Ohio 43017

· That I am knowledgeable in the English language and in the language in which the below identified international document was written, and that I believe the English translation of the attached document
Headlamp Device for Vehicle
JP-A-7-69125
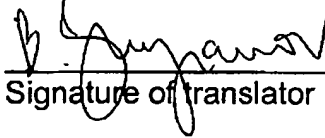is a true and complete translation of the above identified document.

I hereby declare that all statements made herein are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the document.

<u>October 12, 2005</u>
Date

Boris Zhupanov

Full name of translator

Signature of translator